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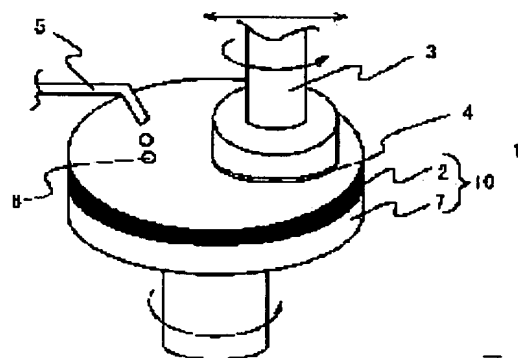
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(54) POLISHING MEMBER, POLISHING METHOD, POLISHING DEVICE, MANUFACTURE OF SEMICONDUCTOR DEVICE AND SEMICONDUCTOR DEVICE

(57)Abstract:

PROBLEM TO BE SOLVED: To heighten the polishing speed and to improve stepped part eliminating performance by forming at least a machining surface part of a polishing member from no-foam resin, suitable for use in a flattening polishing process for a semiconductor device and forming a projecting and recessed part made by concentric, spiral, grid-like groove structure.

SOLUTION: With a polishing agent 6 dropped from a supply part 5 interposed between a polishing pad 2 as a polishing member and a wafer 4 as a material to be polished, both 2, 4 of them are moved relatively to polish the polishing wafer 4. In thus constructed device, at least the machining surface part of the polishing pad 2 is made of non-foam resin and provided with plural projecting and recessed parts of a groove structure. The groove structure is one or combination of two selected from a group of concentric, spiral, grid-like, triangular grid-like and radial grooves, and the section of the recessed part and the projecting part of the projecting and recessed part is rectangular, trapezoidal or triangular. Thus, supplied polishing agent can effectively contribute to polishing to improve polishing efficiency.



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CLAIMS

[Claim(s)]

[Claim 1] In the condition of having made the abrasive material intervening between a polish member and a polish object, by making said polish member and said polish object displaced relatively In said polish member used for the polish equipment which grinds said polish object The polish member characterized by consisting of one as which it has two or more concave heights of said polish member to which the processing surface part changes from non-foamed resin, and changes from slot structure at least, and said slot structure was chosen from the group of the slot of the shape of the shape of concentric circular, a swirl, and a grid, and a triangular grid, and a radial, or two combination or more.

[Claim 2] The polish member according to claim 1 to which the cross section of the crevice (slot) of said concave heights and heights is characterized by having respectively one or more kinds of configurations chosen from a rectangle, a trapezoid, and three square shapes.

[Claim 3] The polish member according to claim 2 to which the configuration of said rectangle, said trapezoid, or said three square shapes is characterized by fulfilling the following conditions.
 $a \geq b$, $b \geq 0$, $c \geq 0$ (here, a is [the die length of the surface of heights and c of the die length of the base of heights and b] the die length of the base of a crevice.)

[Claim 4] The polish member according to claim 3 to which the configuration of said rectangle, said trapezoid, or said three square shapes is characterized by fulfilling the following conditions.
 $0.0 \text{ mm} \leq b \leq 3.0 \text{ mm}$, $0.1 \text{ mm} \leq a + c \leq 5.0 \text{ mm}$, $d \geq 0.1 \text{ mm}$ (here, d is the depth of a crevice.)

[Claim 5] The polish member according to claim 1 characterized by the cross section of the crevice (slot) of said concave heights being the configuration which has the pars convoluta lobuli corticalis renis.

[Claim 6] The polish member according to claim 5 to which the configuration which has said pars convoluta lobuli corticalis renis is characterized by fulfilling the following conditions.

$0.0 \text{ mm} \leq e \leq 3.0 \text{ mm}$, $0.1 \text{ mm} \leq e + f \leq 5.0 \text{ mm}$, $g \geq 0.1 \text{ mm}$ (here, e is [the die length of the surface of a crevice and g of the die length of the surface of heights and f] the depth of a crevice.)

[Claim 7] claims 1-6 characterized by said concave heights having concavo-convex periodic structure -- a polish member any or given in 1 term.

[Claim 8] the resin which is not foamed [said] -- Vickers hardness -- 1.5 kg/mm^2 the above or compression Young's modulus -- 25 kg/mm^2 claims 1-7 characterized by filling the above -- polish member any or given in 1 term.

[Claim 9] the polish approach which grinds said polish object by making said polish member and said polish object displaced relatively in the condition of having made the abrasive material intervening between a polish member and a polish object -- setting -- claims 1-8 -- the polish approach characterized by using a polish member any or given in 1 term.

[Claim 10] It is [the phase of managing the temperature of said polish member, and] said polish member the Vickers hardness of 1.5 kg/mm^2 The above or compression Young's modulus 25 kg/mm^2 The polish approach according to claim 9 characterized by having the phase ground on the conditions with which the above was filled.

[Claim 11] claims 1-8 characterized by said polish object being the wafer with which the semiconductor device was formed -- a polish member any or given in 1 term.

[Claim 12] claims 9 and 10 characterized by said polish object being the wafer with which the semiconductor device was formed -- the polish approach of any or given in 1 term.

[Claim 13] the polish equipment which grinds said polish object by making said polish member and said polish object displaced relatively in the condition of having made the abrasive material intervening between a polish member and a polish object -- setting -- said polish member -- claim 1- 8 and 11 -- the polish

equipment characterized by using a polish member any or given in 1 term.

[Claim 14] The semiconductor device manufacture approach characterized by having the process which carries out flattening of the front face of a semi-conductor silicon wafer using polish equipment according to claim 13.

[Claim 15] The semiconductor device characterized by being manufactured by the semiconductor device manufacture approach according to claim 14.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the suitable polish member for CMP to use for the flattening polish process of the semiconductor device carried out in the process which manufactures semiconductors, such as a polish member and the polish approach, especially ULSI, the polish approach using it, the polish equipment using said polish member, the semiconductor device manufacture approach, and a semiconductor device.

[0002]

[Description of the Prior Art] The process of a semi-conductor manufacture process increases with high integration of a semiconductor integrated circuit, and detailed-izing, and it is becoming complicated. The front face of a semiconductor device is becoming necessarily flat [in connection with this] less. Existence of the level difference in a front face causes the stage piece of wiring, increase of local resistance, etc., and brings about an open circuit and the fall of electric capacity. Moreover, in an insulator layer, it leads also to withstand voltage degradation or generating of leak.

[0003] In connection with the light source wavelength of optical lithography becoming short with high integration of a semiconductor integrated circuit, and detailed-izing, and on the other hand, the so-called NA becoming large the number of open lots, the depth of focus of a semi-conductor aligner is becoming shallow substantially. In order to respond to the depth of focus becoming shallow, flattening on the front face of a device is demanded more than former. As an approach of carrying out flattening of such a semi-conductor front face, the chemical mechanical polish (referred to as CMP from Chemical Mechanical Polishing or Chemical Mechanical Planarization, and this) technique is considered to be a promising approach.

[0004] CMP It is carried out using equipment as shown in drawing 5 . 1 is CMP at drawing 5 . For a polish object and 3, as for a wafer and 5, a polish head and 4 are [equipment and 10 / an abrasive material feed zone and 6] abrasive materials. The polish object 10 sticks a scouring pad 2 on a surface plate 7. Many things of the shape of a sheet which consists of resin of fizz like foaming polyurethane as a scouring pad 2 are used. The polish head 3 is rotated in the direction of an arrow head with a suitable means, and rotates the polish object 10 in the direction of an arrow head with a suitable means. As for a wafer 4, a polished surface-ed is ground by operation of an abrasive material 6 and a scouring pad 2 in this process.

[0005] When using the scouring pad (it is called the scouring pad of fizz below) of the shape of a sheet which consists of resin of the conventional fizz, the polish homogeneity in the whole wafer is good. however, the scouring pad of fizz -- general -- (1) an edge -- (2) with whom [large] When the load was applied, there were problems, such as causing a compression set, from these things, the scouring pad of fizz was the level difference dissolution nature in a wafer with a pattern, and polish surface smoothness was not good. So, by recently, the scouring pad (it is called a non-foamed scouring pad below) which consists of more nearly hard resin with no foaming is examined.

[0006] A non-foamed scouring pad forms in the front face of hard polymeric materials the irregularity which consists of slot structure, and are a polish object and a thing which grinds a wafer front face in this case. By using a non-foamed scouring pad, the problem of the level difference dissolution nature which was a problem at the time of using the scouring pad of fizz was solved.

[0007]

[Problem(s) to be Solved by the Invention] There are the holdout of an abrasive material and the fluidity in a scouring pad front face as an important factor which generally determines the polish rate of a scouring pad. The scouring pad which is not foamed [hard] at the point of the holdout of an abrasive material is less than the scouring pad of fizz. Since an abrasive material will be flown besides a scouring pad according to a

centrifugal force and the holdout of an abrasive material was low when rotating a surface plate at high speed, fixing the scouring pad which is not foamed [conventional] on a surface plate, and supplying an abrasive material, there was a problem that the abrasive material supplied did not contribute to the improvement in a polish rate effectively.

[0008] since it is made in order that this invention may solve this point, and the abrasive material supplied contributes to polish effectively and efficient polish has high possible holdout of an abrasive material and possible fluidity to abrasive material supply -- a polish rate -- high -- and generating of a blemish -- few -- in addition -- and it is making into the technical problem to offer the polish member which is not foamed [excellent in level difference dissolution nature] and the polish approach using this, and polish equipment. [0009] Moreover, this invention attains process increase in efficiency while aiming at the cost cut of a polish process, and it makes it the technical problem to offer the semiconductor device manufacture approach that a semiconductor device can be manufactured by low cost compared with the conventional semiconductor device manufacture approach by that cause, and the semiconductor device of low cost.

[0010]

[Means for Solving the Problem] In order to solve the above-mentioned problem, this invention is in the condition of having made the abrasive material intervening in the first place between "polish member and a polish object. In said polish member used for the polish equipment which grinds said polish object by making said polish member and said polish object displaced relatively Even if there are few said polish members, the processing surface part consists of non-foamed resin. It has two or more concave heights which consist of slot structure, and the polish member (claim 1) characterized by consisting of one as which said slot structure was chosen from the group of the slot of the shape of the shape of concentric circular, a swirl, and a grid and a triangular grid and a radial, or two combination or more" is offered.

[0011] The second is provided with "the polish member (claim 2) according to claim 1 to which the cross section of the crevice (slot) of said concave heights and heights is characterized by having respectively one or more kinds of configurations chosen from a rectangle, a trapezoid, and three square shapes."

[0012] The third is provided with "polish member $a \geq b$ according to claim 2 to which the configuration of said rectangle, said trapezoid, or said three square shapes is characterized by fulfilling the following conditions, $b \geq 0$, $c \geq 0$ (here, a is [the die length of the surface of heights and c of the die length of the base of heights and b] the die length of the base of a crevice.)" (claim 3).

[0013] The fourth is provided with "polish member $0.0 \text{ mm} \leq b \leq 3.0 \text{ mm}$ according to claim 3 to which the configuration of said rectangle, said trapezoid, or said three square shapes is characterized by fulfilling the following conditions, $0.1 \text{ mm} \leq a + c \leq 5.0 \text{ mm}$, $d \geq 0.1 \text{ mm}$ (here, d is the depth of a crevice.) (claim 4)."

[0014] The fifth is provided with "the polish member (claim 5) according to claim 1 characterized by the cross section of the crevice (slot) of said concave heights being the configuration which has the pars convoluta lobuli corticalis renis."

[0015] The sixth is provided with "polish member $0.0 \text{ mm} \leq e \leq 3.0 \text{ mm}$ according to claim 5 to which the configuration which has said pars convoluta lobuli corticalis renis is characterized by fulfilling the following conditions, $0.1 \text{ mm} \leq e + f \leq 5.0 \text{ mm}$, $g \geq 0.1 \text{ mm}$ (here, e is [the die length of the surface of a crevice and g of the die length of the surface of heights and f] the depth of a crevice.) (claim 6)."

[0016] the seventh -- "-- claims 1-6 characterized by said concave heights having concavo-convex periodic structure -- polish member (claim 7)" any or given in 1 term is offered.

[0017] the eighth -- "-- the resin which is not foamed [said] -- Vickers hardness -- 1.5 kg/mm^2 -- the above or compression Young's modulus -- 25 kg/mm^2 -- claims 1-7 characterized by filling the above -- polish member (claim 8)" any or given in 1 term is offered.

[0018] the ninth -- "-- the polish approach which grinds said polish object by making said polish member and said polish object displaced relatively in the condition of having made the abrasive material intervening between a polish member and a polish object -- setting -- claims 1-8 -- polish approach (claim 9)" characterized by using a polish member any or given in 1 term is offered.

[0019] It is [the phase of managing the temperature of the "aforementioned polish member to the tenth, and] said polish member the Vickers hardness of 1.5 kg/mm^2 The above or compression Young's modulus 25 kg/mm^2 Polish approach (claim 10)" according to claim 9 characterized by having the phase ground on the conditions with which the above was filled is offered.

[0020] the eleventh -- "-- claims 1-8 characterized by said polish object being the wafer with which the semiconductor device was formed -- polish member (claim 11)" any or given in 1 term is offered.

[0021] the twelfth -- "-- claims 9 and 10 characterized by said polish object being the wafer with which the semiconductor device was formed -- polish approach (claim 12)" any or given in 1 term is offered.

[0022] the thirteenth -- "-- the polish equipment which grinds said polish object by making said polish member and said polish object displaced relatively in the condition of having made the abrasive material intervening between a polish member and a polish object -- setting -- said polish member -- claim 1- 8 and 11 -- polish equipment (claim 13)" characterized by using a polish member any or given in 1 term is offered.

[0023] The 14th is provided with "the semiconductor device manufacture approach (claim 14) characterized by having the process which carries out flattening of the front face of a semi-conductor silicon wafer using polish equipment according to claim 13."

[0024] The 15th is provided with "the semiconductor device (claim 15) characterized by being manufactured by the semiconductor device manufacture approach according to claim 14."

[0025]

[Embodiment of the Invention] The operation gestalt of this invention is concretely explained using a Fig. below.

[0026] Drawing 1 is drawing showing the enlarged section of the concave heights which consist of the slot structure of the processing surface part of the polish member by the 1st operation gestalt of this invention, in the die length of the base of heights, and b, the die length of the surface of heights and c express the die length of the base of a crevice (slot), and d expresses [a] the depth of flute. As for concave heights, it is desirable to take periodic structure here, p [in / in this case / drawing 1] is the pitch (it is called the pitch of a slot below) of the periodic structure of the irregularity of concave heights, and p-b is the width of face of a slot (upper part of a crevice). In drawing 1, although only the processing surface part of a polish member was shown, as long as it has the slot structure where the processing surface part consists of non-foamed resin at least, the shape of the shape of a sheet and a plate has as the polish member which becomes this invention, and the thing of the shape of a plate cast also by multilayer structure which carried out the laminating of the ingredient of a different kind on the flat-surface plate with rigidity is sufficient as it.

[0027] According to the formula of Preston (Preston), a polish rate is proportional to the pressure in the contact surface of a polish member, not only the relative velocity of a polish object but a polish object, and a polish member here. Since a polish rate is proportional also to an effective interfacial area further, the load per unit area is the same, and when relative velocity is the same, a polish rate improves, so that a touch area is large. Since the contact conditions of a polish member and a polish object differ in the time of un-pressurizing and the pressurization under polish, and since that the hit by the polish member and the polish object is imperfect has the effective semantics of an effective interfacial area, the value with which the touch area under polish is simply calculated from a drawing means [which is a different value] that an effectual (effective) value is taken here. Only by a touch area being large, an abrasive material is not supplied even to all the corners of said contact surface, namely, since the fluidity of an abrasive material becomes low, a polish rate cannot be raised in a non-foamed scouring pad. What is necessary is just to raise the consistency of a slot, in order to supply an abrasive material even to all the corners of said contact surface. However, it is not so effective in improvement in a polish rate only by only merely raising the consistency of a slot and making the gross area of a slot increase. It is because the increment in the gross area of a slot decreases a touch area since the sum of the gross area and touch area of a slot is equal to the area of the processing side of a polish member, and the reduction in a touch area reduces a polish rate from the above argument. Therefore, if the gross area of a slot is made to increase even if it raises the consistency of a slot, the effectiveness of the fluid improvement in an abrasive material, therefore the effectiveness of the improvement in a polish rate will be offset. In order to raise a fluidity and not to reduce a touch area, as for the consistency of a slot, it is inadequate that it is just high, and a flute width must be narrowed at coincidence. By being narrow in the width of face of a slot, and making the pitch of a slot small, and raising the consistency of a slot, an abrasive material is supplied even to all the corners of the contact surface, and a polish rate improves.

[0028] Here, the role of a slot is important. The slot is bearing the function which forms the heights of a polish member, and not only the function to supply an abrasive material to the heights which are the contact surface, and to secure the fluidity of an abrasive material but the important function which discharges polish waste or the polish grain in the condensed abrasive material (it is called the polish grain condensed below) from there. The width of face of a slot has the not much good direction which is not small in the semantics. It is because it will be got blocked into a slot while polish waste or the condensed polish grain being discharged if not much small, so the discharge to the exterior of the processing side of the polish member of polish waste or the condensed polish grain is spoiled, and it becomes the cause of generating of a blemish by contacting a polish object while this grinds.

[0029] For the above reason, the pitch of a slot may be too coarse or must not be too fine conversely, and the width of face of a slot may be too wide, or must not be too narrow conversely, and it has an optimum value respectively.

[0030] In the case of a silicon oxide system slurry, the range of the width of face (p-b) of a desirable slot has 0.05mm or more 4.5 desirablenmm or less at drawing 1 depending on the dimension of the polish waste discharged from there, or the condensed polish grain.

[0031] The pitch p of a slot is decided by the bargain of the property contradictory to each other who is called the basis of a limit of the width of face of the slot limited as mentioned above, the fluid goodness of an abrasive material, and the numerousness of touch areas, and 0.1mm or more its 5.0mm or less is desirable as a result of an experiment. Die-length b of the surface of the heights of a slot has 0.0mm or more 3.0 desirablenmm or less.

[0032] Furthermore, the relation between die-length a of the base of heights and die-length b of the surface is $a \geq b$, die-length b of the surface is $b \geq 0$, and, as for die-length c of the base of a crevice, it is desirable that it is $c \geq 0$. In addition, although the surface of heights becomes edge-like at the time of $b = 0$, since an edge part is compressed and a polish object is contacted in the area of finite in the state of the polish the heights of the shape of this edge are pressurized by whose polish object, an effective interfacial area does not become zero in the time of $b = 0$, either. The minimum of depth-of-flute d is decided from eccentric [of polish waste or the condensed polish grain], and is 0.1mm. The above is desirable.

[0033] Drawing 9 is drawing showing the enlarged section of the concave heights which consist of the slot structure of the processing surface part of the polish member by the 2nd operation gestalt of this invention. In the polish member by the 2nd operation gestalt, although the cross section of a crevice (slot) is U typeface, others omit explanation about the same part as the polish member by the 1st operation gestalt, and the polish member by the 1st operation gestalt since it is the same. In the polish member by the 2nd operation gestalt, in e, the die length of the surface of heights and f express the die length of the surface of a crevice (slot), and g expresses the depth of flute. As for concave heights, it is desirable to take periodic structure here, and p_2 [in / in this case / drawing 9] is the pitch (it is called the pitch of a slot below) of the periodic structure of the irregularity of concave heights.

[0034] In the case of a silicon oxide system slurry, in the polish member by the 2nd operation gestalt as well as the polish member by the 1st operation gestalt, the range of the width of face f of a desirable slot has 0.05mm or more 4.5 desirablenmm or less depending on the dimension of the polish waste discharged from there, or the condensed polish grain.

[0035] The pitch p_2 of a slot is decided by the bargain of the property contradictory to each other who is called the basis of a limit of the width of face of the slot limited as mentioned above, the fluid goodness of an abrasive material, and the numerousness of touch areas, and 0.1mm or more its 5.0mm or less is desirable as a result of an experiment. Die-length e of the surface of the heights of a slot has 0.0mm or more 3.0 desirablenmm or less.

[0036] In addition, although the surface of heights becomes edge-like at the time of $e = 0$, since an edge part is compressed and a polish object is contacted in the area of finite in the state of the polish the heights of the shape of this edge are pressurized by whose polish object, an effective interfacial area does not become zero in the time of $e = 0$, either. The minimum of depth-of-flute g is decided from eccentric [of polish waste or the condensed polish grain], and is 0.1mm. The above is desirable.

[0037] In the 2nd operation gestalt, although the slot whose cross section of a crevice (slot) is U typeface is formed in the processing surface part of a polish member, supply and discharge of an abrasive material are easy in a slot being U typeface, and since the large include angle which the processing side and slot of a polish member make can also be taken, generating of the acute angle part produced in the processing side of a polish member can be suppressed. It is possible to suppress generating of the blemish of a polish object by these.

[0038] In addition, although [the polish member by the 2nd operation gestalt / the cross-section configuration of the crevice (slot) currently formed in the processing side of a polish member] it is U typeface, you may be the configuration which has curvatures other than U typeface.

[0039] In the polish member by the 1st and 2nd operation gestalten, in order to raise a polish rate, and in order to abolish a blemish, the configuration of a slot is important, therefore the pattern suitable for performing effectively eccentric [of the fluidity of an abrasive material, holdout, polish waste, or the condensed polish grain] is chosen. The pattern has one or two desirable combination or more which were chosen from the group of the slot of the shape of the shape of concentric circular, a swirl, and a grid, and a triangular grid, and a radial. Among this, a grid-like slot is shown in drawing 7 and the triangular grid-like

slot is shown for the slot of concentric circular and a radial in drawing 6 at drawing 8.

[0040] As stated above, a polish rate is proportional to a touch area. However, generally contact into a solid-state and a solid-state is a point. Since the hard ingredient is being used for the non-foamed polish member which becomes this invention and its effectual touch area is lower than the value simply calculated from a drawing, it has that a polish rate is lower than expected value. A device is needed in order to familiarize the whole heights with a polish object. Therefore, the temperature dependence of the degree of hardness of the resin of the ingredient of a scouring pad is used. The degree of hardness of resin becomes low with a temperature rise. The hit to a polish object is raised by raising temperature and carrying out temperature management of the degree of hardness of a scouring pad. Signs that the polymeric materials which are ingredients of the polish member of the example of this invention reduce the degree of hardness to drawing 3 with the rise of temperature are shown. A polish rate rises, so that, as for a polish rate, temperature becomes high depending on temperature, as shown in drawing 2. The reactant improvement in a slurry other than the increment in an effective (it is effectual) touch area is one of the causes of a rise of this polish rate.

[0041] One of the descriptions that the polish member which is not foamed [hard] is big is performing efficiently the level difference dissolution of surface smoothness, i.e., a pattern. A fall of the degree of hardness of a polish member worsens the level difference dissolution nature. The experiment which investigates the relation between the degree of hardness of a polish member and level difference dissolution nature was conducted on below. The oxidation silicon (SiO_2) film of 1-micrometer thickness is formed on the 4mmx4mm pattern film of 500nm thickness. 700nm of wafers whose initial level difference is 500nm is ground by the polish member to which the degree of hardness of an ingredient was changed variously. When removed, the Vickers hardness of the ingredient of a polish member is 2 ($1.5 \times 10^7 \text{Pa}$) 1.5kg/mm. The above or compression Young's modulus is 2 ($2.5 \times 10^8 \text{Pa}$) 25kg/mm. When it was above, it turned out that a residual level difference can be set to 150nm or less.

[0042] This to Vickers hardness 1.5kg/mm² The above ($1.5 \times 10^7 \text{Pa}$) or compression Young's modulus 25kg/mm² If the above ($2.5 \times 10^8 \text{Pa}$) can be maintained and it grinds on the conditions that temperature is the highest, both the highest polish rate and good surface smoothness can be obtained.

[0043] The above scouring pad may prepare the measurement aperture for letting a measuring beam pass in one or more places, in order to dig a hole in the suitable location of drawing 6 and the slot structure shown by 7 and 8 and to measure the polish condition under polish optically on that spot. Moreover, in order to prevent blemish generating when a polish object and a polish head contact the field by the side of the polish object of the measurement aperture, it is also desirable to give a rebound ace court and to give an antireflection film to the field of the opposite side. Furthermore, the polish equipment which whose polish rate is [the polish member of this invention] high if it attaches in polish equipment as showed this to drawing 5 of for example, the conventional example, and is excellent in level difference dissolution nature, and does not have generating of a blemish is obtained.

[0044] Drawing 10 is a flow chart which shows a semiconductor device manufacture process. A semiconductor device manufacture process is started, it is step S200 first and suitable down stream processing is chosen out of the next steps S201-S204. It progresses to either of steps S201-S204 according to selection.

[0045] Step S201 is an oxidation process which oxidizes the front face of a silicon wafer. Step S202 is a CVD process which forms an insulator layer in a silicon wafer front face by CVD etc. Step S203 is an electrode formation process which forms an electrode at processes, such as vacuum evaporatio, on a silicon wafer. Step S204 is an ion implantation process which drives ion into a silicon wafer.

[0046] It progresses to step S205 after a CVD process or an electrode formation process. Step S205 is a CMP process. At a CMP process, flattening of an interlayer insulation film, formation of DAMASHIN (damascene) by polish of the metal membrane of the front face of a semiconductor device, etc. are performed by the polish equipment concerning this invention.

[0047] It progresses to step S206 after a CMP process or an oxidation process. Step S206 is a FOTORISO process. At a FOTORISO process, spreading of the resist to a silicon wafer, baking of the circuit pattern to the silicon wafer by the exposure which used the aligner, and development of the exposed silicon wafer are performed. Furthermore, the following step S207 is an etching process which removes the resist which parts other than the developed resist image were deleted by etching, resist exfoliation was performed after that, and etching ended, and became unnecessary.

[0048] Next, it judges whether all processes required of step S208 were completed, if it has not completed, the step of return and the point is repeated to step S200, and a circuit pattern is formed on a silicon wafer. It

will become an end if it is judged that all processes were completed at step S208.

[0049] since the polish equipment applied to this invention in a CMP process is used by the semiconductor device manufacture approach concerning this invention -- abrasive material supply -- receiving -- efficient polish -- possible -- since the holdout of an abrasive material and the fluidity are high -- a polish rate -- high -- and generating of the blemish of a silicon wafer -- few -- in addition -- and it excels in level difference dissolution nature. Since the yield in a CMP process improves and process effectiveness improves by this, it is effective in the ability to manufacture a semiconductor device by low cost compared with the conventional semiconductor device manufacture approach.

[0050] In addition, the polish equipment concerning this invention may be used for the CMP process of semiconductor device manufacture processes other than the above-mentioned semiconductor device manufacture process.

[0051] The semiconductor device concerning this invention is manufactured by the semiconductor device manufacture approach concerning this invention. Thereby, compared with the conventional semiconductor device manufacture approach, a semiconductor device can be manufactured by low cost, and it is effective in the ability to reduce the manufacturing cost of a semiconductor device.

[Example 1] Spiral V groove (the pitch of a slot: 0.5mm, die-length:0.15mm of the surface of heights) The non-foamed sheet which consists of an epoxy resin which has both concaves (5 times spacing, a depth of 0.5mm) of a radial was fixed on the aluminum base plate of phi800mm x20mm, and this was made into the scouring pad.

[0052] Next, bore phi145mm It is elastic membrane 13 (Rodel Nitta make R201) to the ring 12 made from aluminum. It stuck, and this ring 12 was arranged as shown in drawing 4 through O rings 16 and 14, and the polish head shown in drawing 4 was constituted. 15 is a retainer ring and this is a ring for elutriation prevention of the polish object 4. In order that 17 may pressurize the polish object 4, it is the airtight space maintained at positive pressure, and in order to give positive pressure, a compression gas is supplied from 18 and 19. By this airtight space 17 and elastic membrane 13, the polish head has structure which can be pressurized independently of the whole system containing a retainer ring 15.

[0053] It is SiO₂ to elastic membrane 13. The thermal oxidation film is 1. mum 6 formed SHIRIKONEHA of an inch was fixed with surface tension and it ground on the processing conditions shown below.

[0054] a processing condition and number of scouring pad rotations: -- 50rpm and number of polish head rotations: -- 50rpm and rocking distance: -- 30mm and count of rocking: -- 15 Both-way/a part - abrasive material : SEMI Supers25 by Cabot Corp. 2 twice -- dilution and abrasive material flow rate: -- a part for 50ml/-- load to - wafer: 400g/cm² (3.9x10⁴Pa)

The temperature of a platen, therefore the temperature of a scouring pad were maintained at 50 degrees C.

[0055] As a result of grinding the above condition, a part for 200nm/was obtained as a polish rate.

Moreover, when the oxidation silicon (SiO₂) film of 1-micrometer thickness was formed on the 4mmx4mm pattern film of 500nm thickness and only the thickness of 700nm ground and removed the wafer whose initial level difference is 500nm, the residual level difference was 100nm or less, and was good. Moreover, there was also no generating of a blemish.

When temperature of the [example 1 of comparison] scouring pad was made into a room temperature, although the residual level difference was good at 100nm or less, the polish rate fell to a part for 150nm/like the example. There was no generating of a blemish.

Except for having extended the die length of the surface of the heights of the [example 2 of comparison] slot to 0.35mm, it ground by making temperature of a scouring pad into 50 degrees C with the same scouring pad as an example 1. The polish rate fell to a part for 180nm/from a part for 200nm/of an example 1. Since the fluidity of an abrasive material fell, it thinks. There was no generating of a blemish.

[0056]

[Effect of the Invention] Since according to this invention the above passage it can grind at effectiveness equivalent to the conventional fizz scouring pad to the amount of supply of an abrasive material and the fluidity of an abrasive material and the magnitude of a touch area are optimized Since a polish rate is an early and hard pad, level difference dissolution nature is excellent to a wafer with a pattern and the width of face of a slot is optimized further again Discharge of the aggregate of polish waste or an abrasive material is performed smoothly, and the polish approach and polish equipment using the polish member and this which do not have generating of a blemish further again can be offered.

[0057] Moreover, this invention can attain process increase in efficiency while aiming at the cost cut of a polish process, and it can offer the semiconductor device manufacture approach that a semiconductor device can be manufactured by low cost compared with the conventional semiconductor device manufacture

approach by that cause, and the semiconductor device of low cost.

[Translation done.]

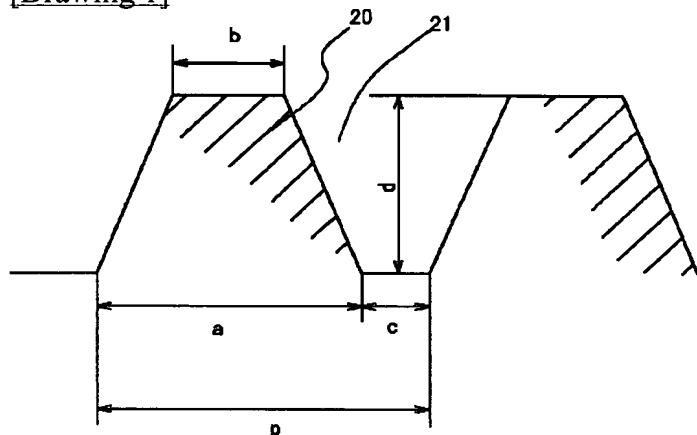
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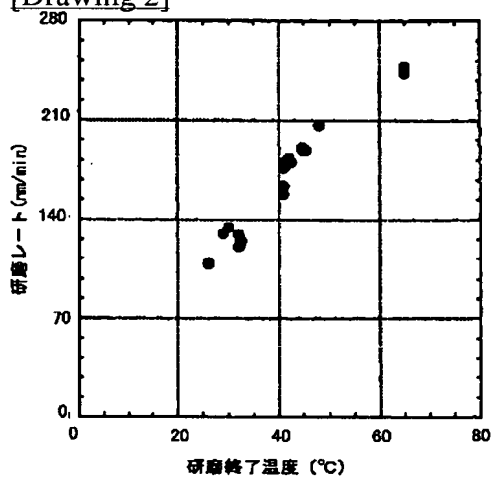
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DRAWINGS

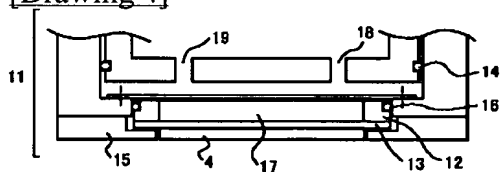
[Drawing 1]



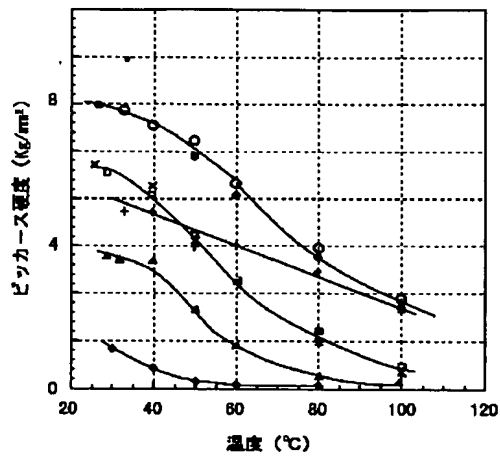
[Drawing 2]



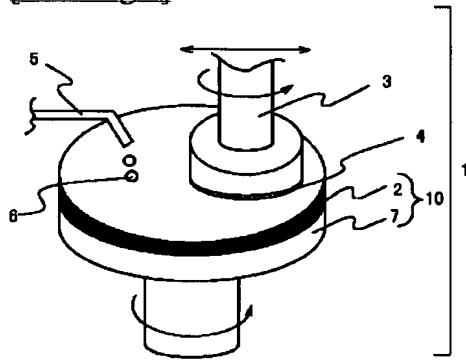
[Drawing 4]



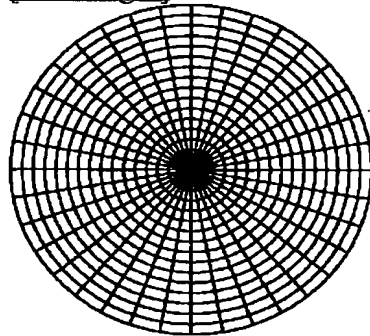
[Drawing 3]



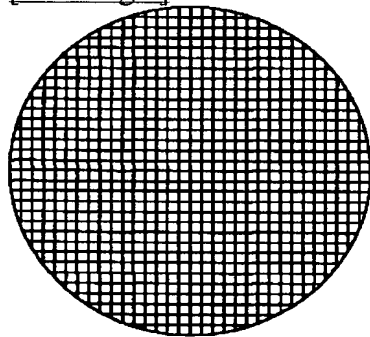
[Drawing 5]



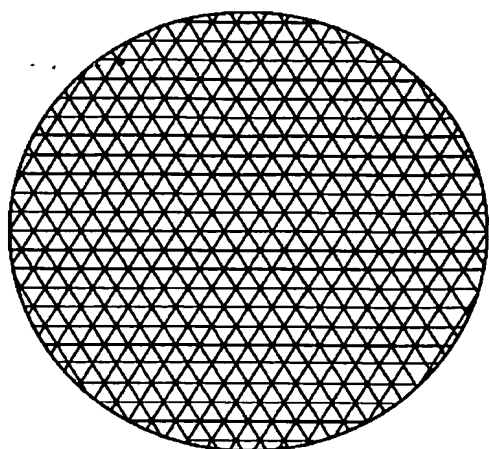
[Drawing 6]



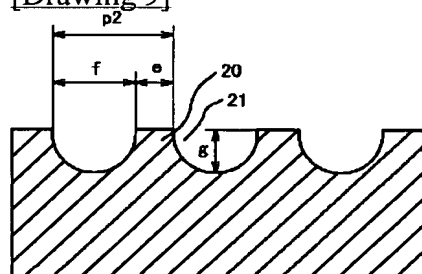
[Drawing 7]



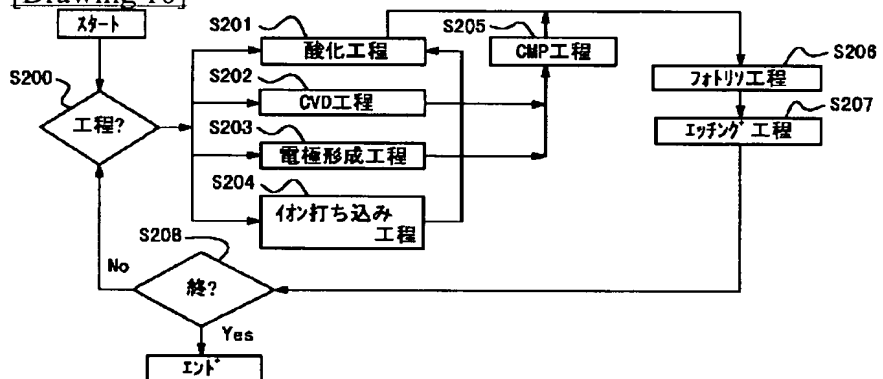
[Drawing 8]



[Drawing 9]



[Drawing 10]



[Translation done.]

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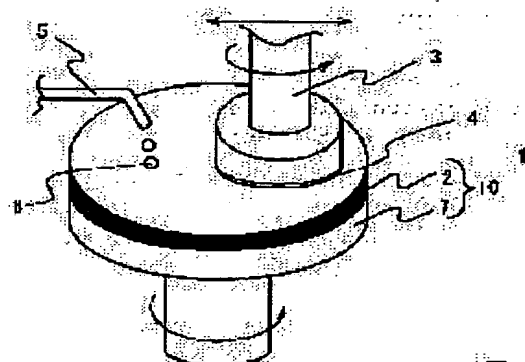
Priority number : 11098179 Priority date : 05.04.1999 Priority country : JP

(54) POLISHING MEMBER, POLISHING METHOD, POLISHING DEVICE, MANUFACTURE OF SEMICONDUCTOR DEVICE AND SEMICONDUCTOR DEVICE

(57)Abstract:

PROBLEM TO BE SOLVED: To heighten the polishing speed and to improve stepped part eliminating performance by forming at least a machining surface part of a polishing member from no-foam resin, suitable for use in a flattening polishing process for a semiconductor device and forming a projecting and recessed part made by concentric, spiral, grid-like groove structure.

SOLUTION: With a polishing agent 6 dropped from a supply part 5 interposed between a polishing pad 2 as a polishing member and a wafer 4 as a material to be polished, both 2, 4 of them are moved relatively to polish the polishing wafer 4. In thus constructed device, at least the machining surface part of the polishing pad 2 is made of non-foam resin and provided with plural projecting and recessed parts of a groove structure. The groove structure is one or combination of two selected from a group of concentric, spiral, grid-like, triangular grid-like and radial grooves, and the section of the recessed part and the projecting part of the projecting and recessed part is rectangular, trapezoidal or triangular. Thus, supplied polishing agent can effectively contribute to polishing to improve polishing efficiency.



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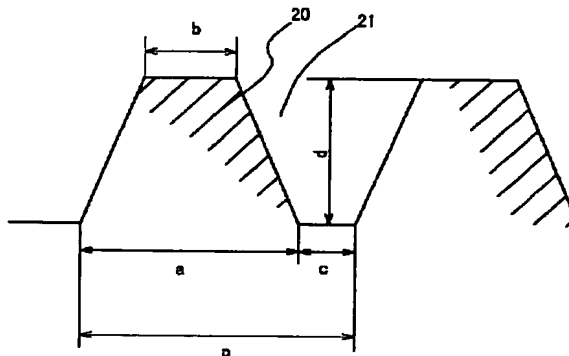
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(54) 【発明の名称】 研磨部材、研磨方法、研磨装置、半導体デバイス製造方法、及び半導体デバイス

(57) 【要約】

【課題】 CMP装置に用いる研磨パッドに於いて、研磨剤の保持性の点で、硬質の無発泡の研磨パッドは、発泡性の研磨パッドに及ばない。本発明はこの点を解決するためになされ、研磨剤供給に対して効率的な研磨が可能な、研磨剤の保持性と流動性が高いために研磨速度が高く、且つ、傷の発生が少なく、尚且つ段差解消性に優れた無発泡の研磨部材及びこれを用いた研磨方法を提供することを課題としている。

【解決手段】 本発明の研磨部材は、研磨部材と研磨対象物との間に研磨剤を介在させた状態で、研磨部材と研磨対象物を相対移動させることにより、研磨対象物を研磨する研磨装置に用いる研磨部材であって、研磨部材の少なくともその加工面部が、無発泡の樹脂から成り、溝構造から成る最適寸法の複数の凹凸部を有し、溝構造が同心円状、螺旋状、格子状、三角格子状、放射状の溝の群から選ばれた一つあるいは二つ以上の組み合わせから成る。



【特許請求の範囲】

【請求項1】研磨部材と研磨対象物との間に研磨剤を介在させた状態で、前記研磨部材と前記研磨対象物を相対移動させることにより、前記研磨対象物を研磨する研磨装置に用いる前記研磨部材において、前記研磨部材の少なくともその加工面部が、無発泡の樹脂から成り、溝構造から成る複数の凹凸部を有し、前記溝構造が同心円状、螺旋状、格子状、三角格子状、放射状の溝の群から選ばれた一つあるいは二つ以上の組み合わせから成ることを特徴とする研磨部材。

【請求項2】前記凹凸部の凹部（溝部）及び凸部の断面が、矩形、台形、及び3角形から選ばれた一種類以上の形状を各々有することを特徴とする請求項1記載の研磨部材。

【請求項3】前記矩形、前記台形、または前記3角形の形状が、以下の条件を充たすことを特徴とする請求項2記載の研磨部材。

$$a \geq b, b \geq 0, c \geq 0$$

（ここで、aは凸部の底辺の長さ、bは凸部の上辺の長さ、cは凹部の底辺の長さである。）

【請求項4】前記矩形、前記台形、または前記3角形の形状が、以下の条件を充たすことを特徴とする請求項3記載の研磨部材。

$$0.0\text{ mm} \leq b \leq 3.0\text{ mm}, 0.1\text{ mm} \leq a + c \leq$$

$$5.0\text{ mm}, d \geq 0.1\text{ mm}$$

（ここで、dは凹部の深さである。）

【請求項5】前記凹凸部の凹部（溝部）の断面が、曲部を有する形状であることを特徴とする請求項1記載の研磨部材。

【請求項6】前記曲部を有する形状が、以下の条件を充たすことを特徴とする請求項5記載の研磨部材。

$$0.0\text{ mm} \leq e \leq 3.0\text{ mm}, 0.1\text{ mm} \leq e + f \leq$$

$$5.0\text{ mm}, g \geq 0.1\text{ mm}$$

（ここで、eは凸部の上辺の長さ、fは凹部の上辺の長さ、gは凹部の深さである。）

【請求項7】前記凹凸部が凹凸の周期構造を有することを特徴とする請求項1～6何れか1項記載の研磨部材。

【請求項8】前記無発泡の樹脂が、ビッカース硬度が1.5 kg/mm²以上または圧縮ヤング率が25 kg/mm²以上を充たすことを特徴とする請求項1～7何れか1項記載の研磨部材。

【請求項9】研磨部材と研磨対象物との間に研磨剤を介在させた状態で、前記研磨部材と前記研磨対象物を相対移動させることにより、前記研磨対象物を研磨する研磨方法において、請求項1～8何れか1項記載の研磨部材を用いることを特徴とする研磨方法。

【請求項10】前記研磨部材の温度を管理する段階と、前記研磨部材をビッカース硬度1.5 kg/mm²以上または圧縮ヤング率25 kg/mm²以上を充たした条件で研磨する段階を有することを特徴とする請求項9記

載の研磨方法。

【請求項11】前記研磨対象物が、半導体デバイスが形成されたウェハであることを特徴とする請求項1～8何れか1項記載の研磨部材。

【請求項12】前記研磨対象物が、半導体デバイスが形成されたウェハであることを特徴とする請求項9、10何れか1項記載の研磨方法。

【請求項13】研磨部材と研磨対象物との間に研磨剤を介在させた状態で、前記研磨部材と前記研磨対象物を相対移動させることにより、前記研磨対象物を研磨する研磨装置において、前記研磨部材に請求項1～8、11何れか1項記載の研磨部材を用いることを特徴とする研磨装置。

【請求項14】請求項13記載の研磨装置を用いて半導体シリコンウェハの表面を平坦化する工程を有することを特徴とする半導体デバイス製造方法。

【請求項15】請求項14記載の半導体デバイス製造方法により製造されることを特徴とする半導体デバイス。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は、研磨部材及び研磨方法、特にULSI等の半導体を製造するプロセスにおいて実施される半導体デバイスの平坦化研磨プロセスに用いるのに好適なCMP用研磨部材、それを用いた研磨方法、前記研磨部材を用いた研磨装置、半導体デバイス製造方法、及び半導体デバイスに関するものである。

【0002】

【従来の技術】半導体集積回路の高集積化、微細化に伴って半導体製造プロセスの工程が増加し複雑になってきている。これに伴い、半導体デバイスの表面は必ずしも平坦ではなくなっている。表面に於ける段差の存在は配線の段切れ、局所的な抵抗の増大などを招き、断線や電気容量の低下をもたらす。また、絶縁膜では耐電圧劣化やリークの発生にもつながる。

【0003】一方、半導体集積回路の高集積化、微細化に伴って光リソグラフィの光源波長は短くなり、開口数いわゆるNAが大きくなってきていることに伴い、半導体露光装置の焦点深度が実質的に浅くなってきている。焦点深度が浅くなることに対応するためには、今まで以上にデバイス表面の平坦化が要求されている。このような半導体表面を平坦化する方法としては、化学的機械的研磨（Chemical Mechanical Polishing又はChemical Mechanical Planarization、これよりCMPと呼ぶ）技術が有望な方法と考えられている。

【0004】CMPは図5に示すような装置を用いて行われている。図5で1はCMP装置、10は研磨体、3は研磨ヘッド、4はウェハ、5は研磨剤供給部、6は研磨剤である。研磨体10は、定盤7の上に研磨パッド2を貼り付けたものである。研磨パッド2としては、発泡ポリウレタンのような発泡性の樹脂よりなるシート状のもの

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が多く用いられている。研磨ヘッド3は適当な手段により矢印方向に回転運動し、また研磨体10は適当な手段により矢印方向に回転運動する。この過程でウェハ4は、研磨剤6と研磨パッド2の作用により被研磨面が研磨される。

【0005】従来の発泡性の樹脂よりなるシート状の研磨パッド（以下発泡性の研磨パッドと呼ぶ）を用いる場合、ウェハ全体での研磨均一性は良い。しかしながら、発泡性の研磨パッドは、一般に、(1) 縁だれが大きい、(2) 荷重がかかると圧縮変形を起こす、などの問題があり、これらのことから、発泡性の研磨パッドは、パターン付のウェハでの段差解消性、即ち、研磨平坦性は良くなかった。そこで、最近では、無発泡でより硬質の樹脂より成る研磨パッド（以下無発泡の研磨パッドと呼ぶ）が検討されている。

【0006】無発泡の研磨パッドは硬質の高分子材料の表面に溝構造から成る凹凸を形成し、研磨対象物、この場合はウェハ表面を研磨するものである。無発泡の研磨パッドを用いることによって、発泡性の研磨パッドを使用した場合の問題であった、段差解消性の問題が解決された。

【0007】

【発明が解決しようとする課題】一般に研磨パッドの研磨速度を決定する重要な因子として研磨パッド表面に於ける研磨剤の保持性と流動性がある。研磨剤の保持性の点で、硬質の無発泡の研磨パッドは、発泡性の研磨パッドに及ばない。従来の無発泡の研磨パッドを定盤上に固定して、研磨剤を供給しながら定盤を高速で回転させた場合には、遠心力により研磨剤が研磨パッドの外に飛ばされてしまうため、研磨剤の保持性が低いので、供給される研磨剤が有効に研磨速度向上に寄与しないという問題があった。

【0008】本発明はこの点を解決するためになされたものであり、供給される研磨剤が有効に研磨に寄与し、研磨剤供給に対して効率的な研磨が可能な、研磨剤の保持性と流動性が高いために研磨速度が高く、且つ、傷の発生が少なく、尚且つ段差解消性に優れた無発泡の研磨部材及びこれを用いた研磨方法、研磨装置を提供することを課題としている。

【0009】また、本発明は、研磨工程のコストダウンを図るとともに工程効率化を図り、それにより従来の半導体デバイス製造方法に比べて低コストで半導体デバイスを製造することができる半導体デバイス製造方法、及び低コストの半導体デバイスを提供することを課題としている。

【0010】

【課題を解決するための手段】上記問題を解決する為に、本発明は第一に「研磨部材と研磨対象物との間に研磨剤を介在させた状態で、前記研磨部材と前記研磨対象物を相対移動させることにより、前記研磨対象物を研磨

する研磨装置に用いる前記研磨部材において、前記研磨部材の少なくともその加工面部が、無発泡の樹脂から成り、溝構造から成る複数の凹凸部を有し、前記溝構造が同心円状、螺旋状、格子状、三角格子状、放射状の溝の群から選ばれた一つあるいは二つ以上の組み合わせから成ることを特徴とする研磨部材（請求項1）」を提供する。

【0011】第二に「前記凹凸部の凹部（溝部）及び凸部の断面が、矩形、台形、及び3角形から選ばれた一種類以上の形状を各々有することを特徴とする請求項1記載の研磨部材（請求項2）」を提供する。

【0012】第三に「前記矩形、前記台形、または前記3角形の形状が、以下の条件を充たすことを特徴とする請求項2記載の研磨部材

$$a \geq b, b \geq 0, c \geq 0$$

（ここで、aは凸部の底辺の長さ、bは凸部の上辺の長さ、cは凹部の底辺の長さである。）（請求項3）」を提供する。

【0013】第四に「前記矩形、前記台形、または前記3角形の形状が、以下の条件を充たすことを特徴とする請求項3記載の研磨部材

$$0.0\text{mm} \leq b \leq 3.0\text{mm}, 0.1\text{mm} \leq a + c \leq 5.0\text{mm}, d \geq 0.1\text{mm}$$

（ここで、dは凹部の深さである。）（請求項4）」を提供する。

【0014】第五に「前記凹凸部の凹部（溝部）の断面が、曲部を有する形状であることを特徴とする請求項1記載の研磨部材（請求項5）」を提供する。

【0015】第六に「前記曲部を有する形状が、以下の条件を充たすことを特徴とする請求項5記載の研磨部材

$$0.0\text{mm} \leq e \leq 3.0\text{mm}, 0.1\text{mm} \leq e + f \leq 5.0\text{mm}, g \geq 0.1\text{mm}$$

（ここで、eは凸部の上辺の長さ、fは凹部の上辺の長さ、gは凹部の深さである。）（請求項6）」を提供する。

【0016】第七に「前記凹凸部が凹凸の周期構造を有することを特徴とする請求項1～6何れか1項記載の研磨部材（請求項7）」を提供する。

【0017】第八に「前記無発泡の樹脂が、ビッカース硬度が 1.5kg/mm^2 以上または圧縮ヤング率が 25kg/mm^2 以上を充たすことを特徴とする請求項1～7何れか1項記載の研磨部材（請求項8）」を提供する。

【0018】第九に「研磨部材と研磨対象物との間に研磨剤を介在させた状態で、前記研磨部材と前記研磨対象物を相対移動させることにより、前記研磨対象物を研磨する研磨方法において、請求項1～8何れか1項記載の研磨部材を用いることを特徴とする研磨方法（請求項9）」を提供する。

【0019】第十に「前記研磨部材の温度を管理する段

階と、前記研磨部材をビッカース硬度 1.5 kg/mm^2 以上または圧縮ヤング率 25 kg/mm^2 以上を充たした条件で研磨する段階を有することを特徴とする請求項9記載の研磨方法（請求項10）」を提供する。

【0020】第十一に「前記研磨対象物が、半導体デバイスが形成されたウェハであることを特徴とする請求項1～8何れか1項記載の研磨部材（請求項11）」を提供する。

【0021】第十二に「前記研磨対象物が、半導体デバイスが形成されたウェハであることを特徴とする請求項9、10何れか1項記載の研磨方法（請求項12）」を提供する。

【0022】第十三に「研磨部材と研磨対象物との間に研磨剤を介在させた状態で、前記研磨部材と前記研磨対象物を相対移動させることにより、前記研磨対象物を研磨する研磨装置において、前記研磨部材に請求項1～8、11何れか1項記載の研磨部材を用いることを特徴とする研磨装置（請求項13）」を提供する。

【0023】第十四に「請求項13記載の研磨装置を用いて半導体シリコンウェハの表面を平坦化する工程を有することを特徴とする半導体デバイス製造方法（請求項14）」を提供する。

【0024】第十五に「請求項14記載の半導体デバイス製造方法により製造されることを特徴とする半導体デバイス（請求項15）」を提供する。

【0025】

【発明の実施の形態】以下図を用いて、本発明の実施形態を具体的に説明する。

【0026】図1は本発明の第1の実施形態による研磨部材の加工面部の溝構造から成る凹凸部の拡大断面を示す図であり、aは凸部の底辺の長さ、bは凸部の上辺の長さ、cは凹部（溝部）の底辺の長さ、dは溝の深さを表している。ここで、凹凸部は周期構造を取ることが好ましく、この場合、図1に於けるpは凹凸部の凹凸の周期構造のピッチ（以下溝のピッチと呼ぶ）であり、p-bは溝（凹部の上部）の幅である。図1では、研磨部材の加工面部のみを示したが、本発明になる研磨部材は、少なくともその加工面部が無発泡の樹脂から成る溝構造を有していれば、シート状でもプレート状でも良く、また異種の材料を積層した多層構造でも、剛性のある平面プレート上に成型されたプレート状のものでも良い。

【0027】ここでプレストン（Preston）の式によれば、研磨速度は、研磨部材と研磨対象物の相対速度のみならず、研磨対象物と研磨部材との接触面での圧力に比例する。研磨速度は、更に有効接触面積にも比例するので、単位面積当たりの荷重が同一で相対速度が同一の時、接触面積は大きいほど研磨速度は向上する。ここで有効接触面積の有効の意味は、研磨部材と研磨対象物との接触状態は、未加圧時と研磨中の加圧時とは異なるため、また、研磨部材と研磨対象物との当たりが不完全

なことがあるため、研磨中の接触面積は、図面から単純に計算される値とは異なる値である、実効的（有効的）な値を取るという意味である。無発泡の研磨パッドでは、接触面積が単に大きいだけでは、研磨剤が前記接触面の隅々にまで供給されない、即ち研磨剤の流動性が低くなるために、研磨速度を上げることができない。研磨剤が前記接触面の隅々にまで供給されるようにするには、溝の密度を高めれば良い。しかしながら、ただ単に溝の密度を高め、溝の総面積を増加させるだけでは、研磨速度の向上に余り有効ではない。溝の総面積と接触面積の和は、研磨部材の加工面の面積に等しいから、溝の総面積の増加は接触面積を減少させ、接触面積の減少は以上の議論から研磨速度を低下させるからである。従って、溝の密度を高めても、溝の総面積を増加させると、研磨剤の流動性向上の効果、従って研磨速度向上の効果を相殺するであろう。流動性を高め、且つ、接触面積を減らさないためには、溝の密度は高いだけでは不充分であり、同時に溝幅を狭くしなければならない。溝の幅を狭く、且つ、溝のピッチを小さくし、溝の密度を高めることによって、研磨剤が接触面の隅々にまで供給され、研磨速度が向上するのである。

【0028】ここで、重要なのは溝の役割である。溝は研磨部材の凸部を形成する機能、研磨剤を接触面である凸部に供給して研磨剤の流動性を確保する機能のみならず、研磨屑または凝集した研磨剤中の研磨粒（以下凝集した研磨粒と呼ぶ）をそこから排出する重要な機能を担っているのである。その意味で余り溝の幅は小さくない方が良い。余り小さいと、研磨屑または凝集した研磨粒が排出される途中で溝の中に詰まってしまうため、研磨屑または凝集した研磨粒の研磨部材の加工面の外部への排出が損なわれ、これが研磨中に研磨対象物に接触することによって傷の発生の原因になるからである。

【0029】以上の理由により、溝のピッチは、粗過ぎても、逆に細か過ぎても良くなく、また、溝の幅は広過ぎても、逆に狭過ぎても良くなく、各々最適値を有する。

【0030】図1で、好ましい溝の幅（p-b）の範囲はそこから排出される研磨屑または凝集した研磨粒の寸法に依存し、酸化シリコン系スラリーの場合0.05mm以上4.5mm以下が好ましい。

【0031】溝のピッチpは、以上のように限定された溝の幅の制限のもと、研磨剤の流動性の良さと、接触面積の多さというお互いに矛盾する特性のバーゲンにより決まり、実験の結果、0.1mm以上5.0mm以下が好ましい。溝の凸部の上辺の長さbは、0.0mm以上3.0mm以下が好ましい。

【0032】更に、凸部の底辺の長さaと上辺の長さbとの関係は、 $a \geq b$ であり、上辺の長さbは、 $b \geq 0$ であり、凹部の底辺の長さcは、 $c \geq 0$ であることが好ましい。尚、 $b = 0$ のときは凸部の上辺はエッチ状になる

が、このエッチ状の凸部が研磨対象物に加圧される研磨状態では、エッチ部分は圧縮され、有限の面積で研磨対象物に接触するので、 $b=0$ のときでも有効接触面積は零にはならない。溝の深さ d の下限は研磨屑または凝集した研磨粒の排出性から決まり、 0.1mm 以上が好ましい。

【0033】図9は本発明の第2の実施形態による研磨部材の加工面部の溝構造から成る凹凸部の拡大断面を示す図である。第2の実施形態による研磨部材では、凹部（溝部）の断面がU字形であるが、その他は、第1の実施形態による研磨部材と同様であるので、第1の実施形態による研磨部材と同様の部分については説明を省略する。第2の実施形態による研磨部材において、 e は凸部の上辺の長さ、 f は凹部（溝部）の上辺の長さ、 g は溝の深さを表している。ここで、凹凸部は周期構造を取ることが好ましく、この場合、図9に於ける $p2$ は凹凸部の凹凸の周期構造のピッチ（以下溝のピッチと呼ぶ）である。

【0034】第1の実施形態による研磨部材と同様に、第2の実施形態による研磨部材では、好ましい溝の幅 f の範囲はそこから排出される研磨屑または凝集した研磨粒の寸法に依存し、酸化シリコン系スラリーの場合、 0.05mm 以上 4.5mm 以下が好ましい。

【0035】溝のピッチ $p2$ は、以上のように限定された溝の幅の制限のもと、研磨剤の流動性の良さと、接触面積の多さというお互いに矛盾する特性のバグンにより決まり、実験の結果、 0.1mm 以上 5.0mm 以下が好ましい。溝の凸部の上辺の長さ e は、 0.0mm 以上 3.0mm 以下が好ましい。

【0036】尚、 $e=0$ のときは凸部の上辺はエッチ状になるが、このエッチ状の凸部が研磨対象物に加圧される研磨状態では、エッチ部分は圧縮され、有限の面積で研磨対象物に接触するので、 $e=0$ のときでも有効接触面積は零にはならない。溝の深さ g の下限は研磨屑または凝集した研磨粒の排出性から決まり、 0.1mm 以上が好ましい。

【0037】第2の実施形態においては、研磨部材の加工面部に凹部（溝部）の断面がU字形である溝が形成されているが、溝がU字形であると、研磨剤の供給や排出が容易であり、且つ、研磨部材の加工面と溝とがなす角度も大きく取れるので、研磨部材の加工面に生じる鋭角な部分の発生を抑えられる。これらにより、研磨対象物の傷の発生を抑えることが可能である。

【0038】なお、第2の実施形態による研磨部材では、研磨部材の加工面に形成されている凹部（溝部）の断面形状をU字形であるとしたが、U字形以外の曲率を有する形状であっても良い。

【0039】第1及び第2の実施形態による研磨部材において、研磨速度を向上させるため、また傷をなくするために、溝の形状は重要であり、そのために、研磨剤の

流動性と保持性、研磨屑または凝集した研磨粒の排出性を効果的に行うのに適したパターンが選ばれる。そのパターンは、同心円状、螺旋状、格子状、三角格子状、放射状の溝の群から選ばれた一つあるいは二つ以上の組み合わせが好ましい。この内、同心円状と放射状の溝が図6に、格子状の溝が図7に、三角格子状の溝が図8に示されている。

【0040】以上述べたように、研磨速度は接触面積に比例する。ところが、一般に固体と固体との接触は点である。本発明になる無発泡の研磨部材は、硬質の材料を使っているので、実効的な接触面積が、図面から単純に計算される値よりも低いために、研磨速度が期待値よりも低いことがある。凸部全体を研磨対象物になじませるためには工夫が要る。そのために、研磨パッドの材料の樹脂の硬度の温度依存性を利用する。樹脂の硬度は温度上昇と共に低くなる。研磨パッドの硬度を温度を上昇させ、また温度管理することによって研磨対象物に対する当たりを向上させるのである。図3には本発明の実施例の研磨部材の材料である高分子材料が温度の上昇と共にその硬度を低下させる様子を示している。図2に示すように、研磨速度は温度に依存して、温度が高くなるほど研磨速度は上昇する。この研磨速度の上昇の原因には、有効（実効的な）接触面積の増加の他に、スラリーの反応性の向上がある。

【0041】硬質の無発泡の研磨部材の大きな特徴の一つは平坦性、即ちパターンの段差解消を効率良く行うことである。研磨部材の硬度が低下すると、その段差解消性は悪化する。以下に、研磨部材の硬度と段差解消性との関係を調べる実験をした。500nm厚の4mm×4mmのパターン膜の上に1μm厚の酸化珪素（SiO₂）膜が形成され、初期段差が500nmのウェハを、材料の硬度を様々に変化した研磨部材で700nm研磨、除去したところ、研磨部材の材料のピッカース硬度が1.5kg/mm²（1.5×10⁷Pa）以上、あるいは圧縮ヤング率が25kg/mm²（2.5×10⁸Pa）以上のときに、残留段差を150nm以下にすることができることが分かった。

【0042】このことから、ピッカース硬度1.5kg/mm²（1.5×10⁷Pa）以上、あるいは圧縮ヤング率25kg/mm²（2.5×10⁸Pa）以上を維持でき、且つ最も温度の高い条件で研磨を行えば、最も高い研磨速度と良好な平坦性の両方を得ることができる。

【0043】以上の研磨パッドは、図6、7、8で示した溝構造の適当な場所に孔を穿ち、研磨中の研磨状態をその場で光学的に測定するために、測定光を通すための測定窓を一方所以上に設けても良い。また、その測定窓の研磨対象物側の面に研磨対象物、研磨ヘッドが接触したときの傷発生を防止するために、ハードコートを施し、その反対側の面に反射防止膜を施すのも好ましい。

更に本発明の研磨部材は、これを例えば従来例の図5に示したような研磨装置に取り付ければ、研磨速度が高く、段差解消性に優れ、且つ傷の発生のない研磨装置が得られる。

【0044】図10は半導体デバイス製造プロセスを示すフローチャートである。半導体デバイス製造プロセスをスタートして、まずステップS200で、次に挙げるステップS201～S204の中から適切な処理工程を選択する。選択に従って、ステップS201～S204のいずれかに進む。

【0045】ステップS201はシリコンウエハの表面を酸化させる酸化工程である。ステップS202はCVD等によりシリコンウエハ表面に絶縁膜を形成するCVD工程である。ステップS203はシリコンウエハ上に電極を蒸着等の工程で形成する電極形成工程である。ステップS204はシリコンウエハにイオンを打ち込むイオン打ち込み工程である。

【0046】CVD工程もしくは電極形成工程の後で、ステップS205に進む。ステップS205はCMP工程である。CMP工程では本発明に係る研磨装置により、層間絶縁膜の平坦化や、半導体デバイスの表面の金属膜の研磨によるダマシネ（damascene）の形成等が行われる。

【0047】CMP工程もしくは酸化工程の後でステップS206に進む。ステップS206はフォトリソ工程である。フォトリソ工程では、シリコンウエハへのレジストの塗布、露光装置を用いた露光によるシリコンウエハへの回路パターンの焼き付け、露光したシリコンウエハの現像が行われる。さらに次のステップS207は現像したレジスト上像以外の部分をエッチングにより削り、その後レジスト剥離が行われ、エッチングが済んで不要となったレジストを取り除くエッチング工程である。

【0048】次にステップS208で必要な全工程が完了したかを判断し、完了していなければステップS200に戻り、先のステップを繰り返して、シリコンウエハ上に回路パターンが形成される。ステップS208で全工程が完了したと判断されればエンドとなる。

【0049】本発明に係る半導体デバイス製造方法では、CMP工程において本発明に係る研磨装置を用いているため、研磨剤供給に対して効率的な研磨が可能であり、研磨剤の保持性と流動性が高いために研磨速度が高く、且つ、シリコンウエハの傷の発生が少なく、尚且つ段差解消性に優れている。これにより、CMP工程での歩留まりが向上し、且つ工程効率が向上するので、従来の半導体デバイス製造方法に比べて低コストで半導体デバイスを製造することができるという効果がある。

【0050】なお、上記の半導体デバイス製造プロセス以外の半導体デバイス製造プロセスのCMP工程に本発明に係る研磨装置を用いても良い。

【0051】本発明に係る半導体デバイスは、本発明に係る半導体デバイス製造方法により製造される。これにより、従来の半導体デバイス製造方法に比べて低コスト

で半導体デバイスを製造することができ、半導体デバイスの製造原価を低下させることができるという効果がある。

【実施例1】螺旋状のV溝（溝のピッチ：0.5mm、凸部の上辺の長さ：0.15mm）と放射状の凹溝（5度間隔、深さ0.5mm）の両方を有するエポキシ樹脂からなる、無発泡のシートをφ800mm×20mm tのアルミベースプレート上に固定し、これを研磨パッドとした。

【0052】次に、内径φ145mmのアルミニウム製リング12に弾性膜13（ロデールニッタ製R201）を貼り、このリング12を、Oリング16、14を介して図4に示されるように配し、図4に示す研磨ヘッドを構成した。15はリテーナリングであり、これは研磨対象物4の飛び出し防止用のリングである。17は研磨対象物4を加圧するために正圧に保たれた気密空間であり、正圧を与えるために圧縮気体が18、19から供給される。この気密空間17と弾性膜13とにより、研磨ヘッドは、リテーナリング15を含んだ全体系と独立に加圧出来る構造になっている。

【0053】弾性膜13にSiO₂の熱酸化膜が1μm形成された6インチのシリコンウエハを表面張力で固定し、以下に示す加工条件で研磨を行った。

【0054】加工条件

- ・研磨パッド回転数：50rpm
- ・研磨ヘッド回転数：50rpm
- ・揺動距離：30mm
- ・揺動回数：15 往復/分
- ・研磨剤：キャボット社製SBMI Supers25 を2倍に希釈
- ・研磨剤流量：50ml/分

・ウエハへの荷重：400g/cm²（3.9×10⁴Pa）
プラテンの温度、従って研磨パッドの温度は50℃に維持した。

【0055】以上の条件で研磨した結果、研磨速度として200nm/分が得られた。また、500nm厚の4mm×4mmのパターン膜の上に1μm厚の酸化珪素（SiO₂）膜を形成し、初期段差が500nmのウエハを、700nmの厚みだけ研磨、除去したところ、残留段差は100nm以下であり、良好であった。また、傷の発生もなかった。

【比較例1】研磨パッドの温度を室温にした時、実施例と同様に、残留段差は100nm以下で良好であったが、研磨速度は150nm/分に低下した。傷の発生はなかった。

【比較例2】溝の凸部の上辺の長さを0.35mmに広げたことを除いて、実施例1と同様の研磨パッドで、研磨パッドの温度を50℃にして研磨を行った。研磨速度は実施例1の200nm/分から180nm/分に低下した。研磨剤の流動性が低下したためと考えられる。傷の発生はなかった。

【0056】

【発明の効果】以上の通り、本発明によれば、研磨剤の供給量に対して従来の発泡性研磨パッドと同等の効率で研磨可能であり、且つ研磨剤の流動性と接触面積の大きさが最適化されているので、研磨速度が早く、また硬質パッドであることからパターン付きウェハに対して段差解消性が優れ、更にまた溝の幅が最適化されているので、研磨屑や研磨剤の凝集物の排出がスムーズに行われ、更にまた傷の発生がない研磨部材及びこれを用いた研磨方法、研磨装置を提供できる。

【0057】また、本発明は、研磨工程のコストダウンを図るとともに工程効率化を図り、それにより従来の半導体デバイス製造方法に比べて低コストで半導体デバイスを製造することができる半導体デバイス製造方法、及び低コストの半導体デバイスを提供することができる。

【図面の簡単な説明】

【図1】本発明の第1の実施形態における溝構造の断面構造を説明する図である。

【図2】研磨速度と温度との関係を示す図である。

【図3】研磨部材の硬度と温度との関係を示す図である。

【図4】本発明に用いた研磨ヘッドの図である。

【図5】CMP研磨装置の従来例を示す図である。

【図6】本発明の研磨部材の同心円状と放射状溝の組み合わせの溝構造の平面図を示す。

【図7】本発明の研磨部材の格子状溝の溝構造の平面図を示す。

*

*【図8】本発明の研磨部材の三角格子状溝の溝構造の平面図を示す。

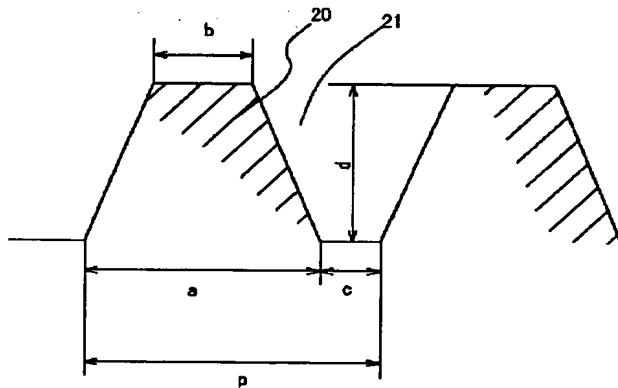
【図9】本発明の第2の実施形態における溝構造の断面構造を説明する図である。

【図10】半導体デバイス製造プロセスを示すフローチャートである。

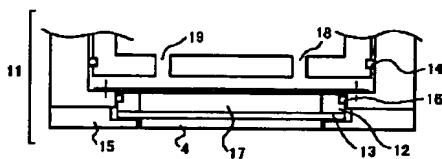
【符号の説明】

- 1 CMP装置
- 2 研磨部材（研磨パッド）
- 3 研磨対象物保持部（研磨ヘッド）
- 4 研磨対象物（ウェハ）
- 5 研磨剤供給部
- 6 研磨剤
- 7 定盤
- 10 研磨体
- 11 研磨対象物保持部（研磨ヘッド）の主要部
- 12 アルミニウム製リング
- 13 弾性膜
- 14 Oリング
- 20 リテーナリング
- 16 Oリング
- 17 気密空間
- 18 高圧気体流入孔
- 19 高圧気体流入孔
- 20 凸部
- 21 凹部（溝部）

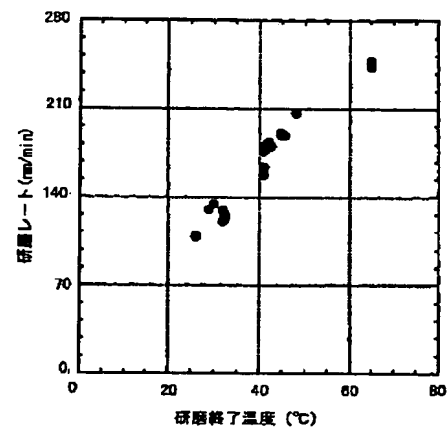
【図1】



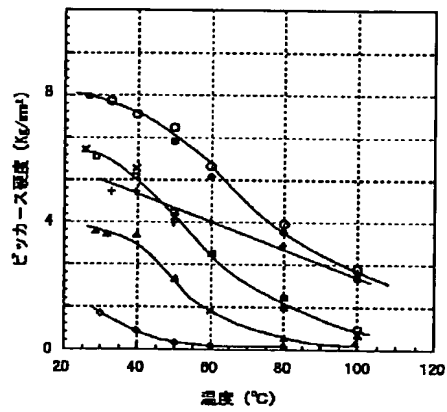
【図4】



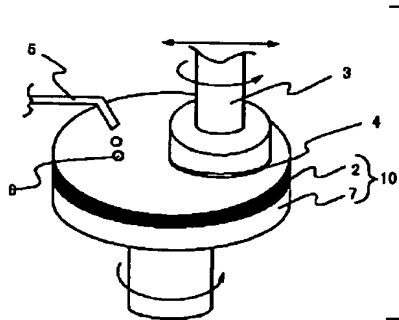
【図2】



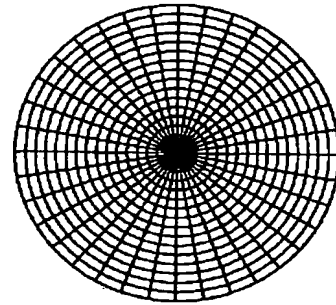
【図3】



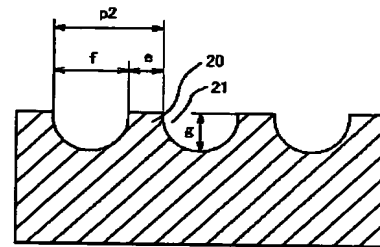
【図5】



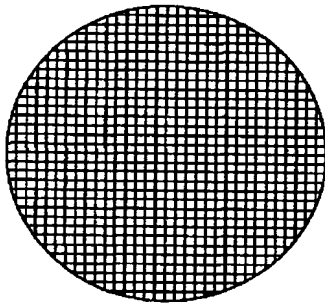
【図6】



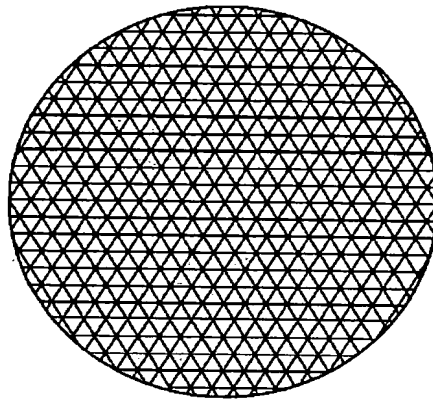
【図9】



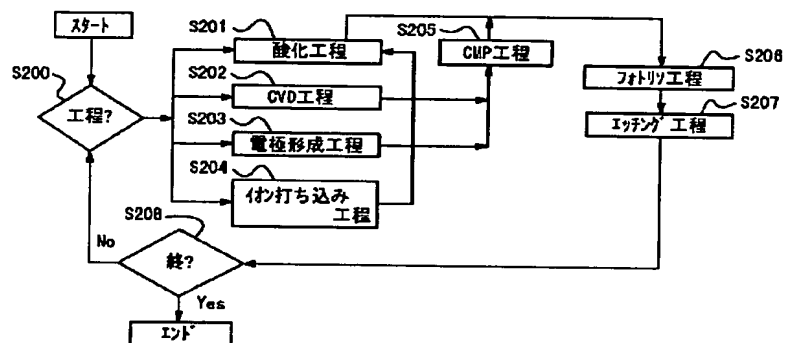
【図7】



【図8】



【図10】



フロントページの続き

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